H. MAHESWARI DEVI* & V. ARUNA LAKSHMI*: **Reproductive behaviour of *Cleome aspera* Koeng. (Capparaceae)**

H. マヘスワリ デビ・V. アルナ ラクシュミ: フウチョウソウ属 *Cleome aspera* Koeng. の胚学的研究

Cleome aspera belongs to the subfamily Cleomoideae of the family Capparaceae. It is a much branched prostrate or ascending herb. Seeds germinate with the onset of the monsoon and the plants appear during July and October. Although a little embryological work has been done in the subfamily Cleomoideae (Mauritzon 1934; Raghavan 1937; Sachar 1956; Prakasa Rao & Hanumantharao 1976; Arunalakshmi 1985b) no attempt has been made to correlate the development of various floral parts. In view of the apparently faster events of post-fertilization maturity observed in *C. aspera,* an attempt has been made to unravel its reproductive behaviour from anthesis to seed dispersal.

Material and methods Experiments are conducted on the plants (*C. aspera*) growing around Andhra University campus. Growth of the buds, flowers, anthesis, fruiting and seed dispersal are recorded. The bud and fruit growth are observed at an interval of 24 hours for about 2 months (from 11. 8. 1982 to 10. 10. 1982). The exact time of anthesis is noted. Flowers are bagged appropriately in order to obtain more accurate results. Buds, flowers and fruits of various developmental stages are fixed in Formalin-acetic-alcohol. Customary methods of microtechnique is followed (Johansen, 1940). The sections cut between 6-15 μm are stained in Delafield's haematoxylin. In vitro pollen germination tests are conducted using 'hanging drop' method.

Observations Organogeny. The floral organs arise in acropetal succession. The sepal primordia make their appearance followed by those of the petals and stamens. The carpel primordia are the last to appear and are lateral in position.

Microsporangium, microsporogenesis and male gemetophyte. The flower bud at the time of differentiation of the anther primordium measures about 0.2 mm in length. The anther primordium soon attains a four lobed contour and the anther becomes tetrasporangiate. In each of the lobes two or three rows of

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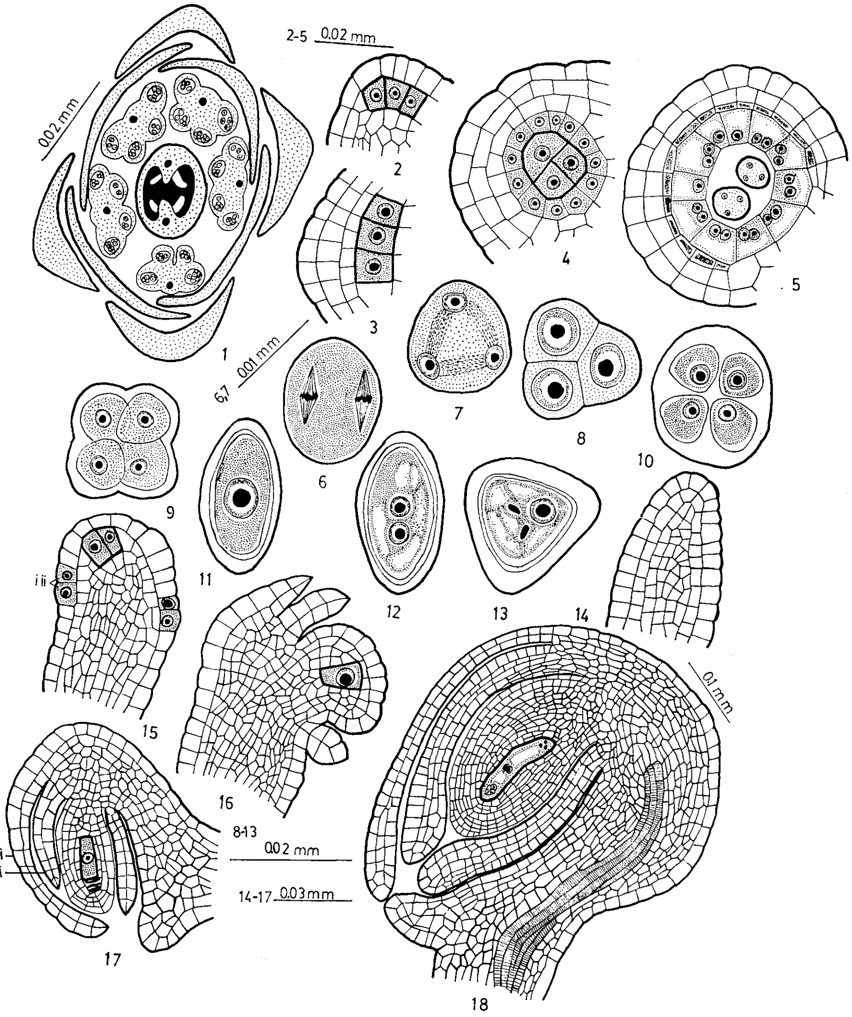


Figs. 1-18. 1. Transverse section of flower showing sepals, petals, anthers and ovary. 2-5. Transverse section of anther lobes showing development of wall layers and sporogenous tissues. 6, 7, Pollen mother cells in meiosii. 8-10. Tetrahedral, decussate and isobilateral tetrads. 11-13, Pollen grains. 14-17. Longitudinal sections of developing ovules. 18. Mature ovule. ii: inner integument; iii: initials of inner integument; oi: outer integument.

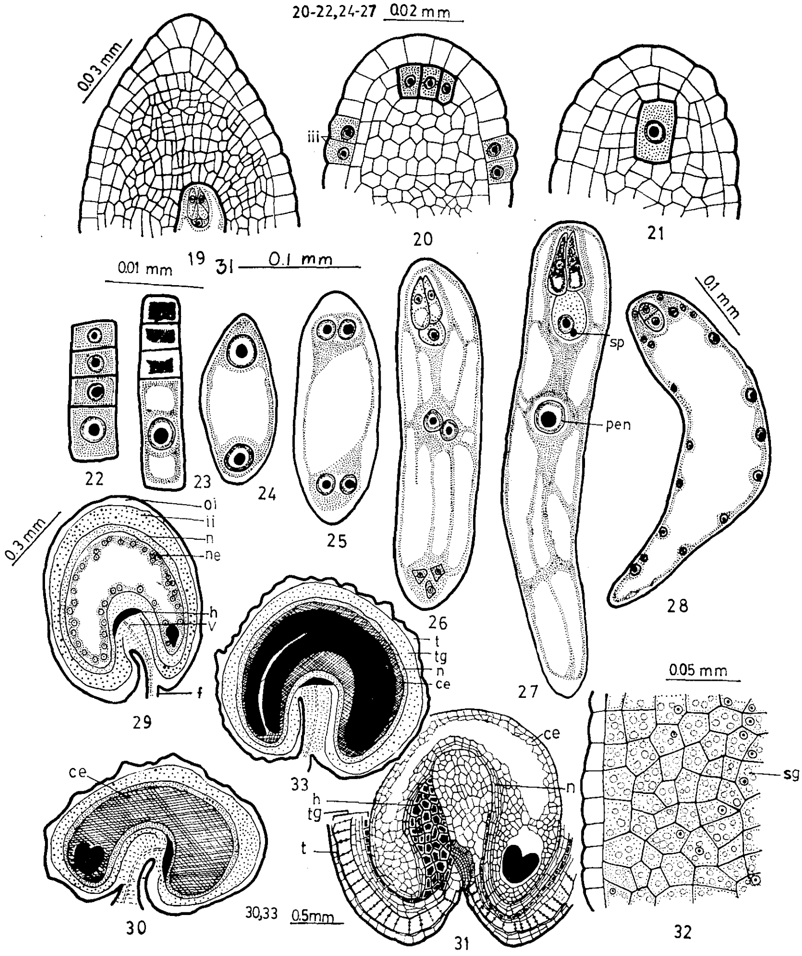
archesporial cells differentiate (Fig. 2). The anther wall development follows the Dicotyledonous pattern (Davis 1966) and comprises the tapetum, middle layer and endothecium below the epidermis (Figs. 3, 4). At about this time the bud measures 1 mm in length. The tapetum is secretory, monomorphic and uniseriate with binucleate cells (Fig. 5). Middle layer is ephemeral and the endothecium develops fibrous thickenings prior to dehiscence of the anther.

The primary sporogenous cells undergo one or two mitotic divisions and form pollen mother cells (Fig. 5). Simultaneous cytokinesis in the pollen mother cells results in the formation of tetrahedral and decussate tetrads (Figs. 6–9). Occasionally isobilateral tetrads are also formed (Fig. 10). By the time the flower bud is 1.3 mm long the microspores are liberated from the matrix. Pollen grain is prolate, tricolporate and 2-celled at shed (Figs. 11, 12). However, in a rare instance 3-celled pollen grain is observed (Fig. 13).

Ovary and ovule. The ovary is superior, bicarpellary syncarpous and unilocular with campylotropous, bitegmic and crassinucellate ovules arranged in two rows on each of the two parietal placentae (Fig. 1). The ovular primordium takes its appearance as a small protuberance on the margin of the placenta by the time second meiotic division is completed in the pollen mother cells (Figs. 1, 14). The integuments are dermal in origin and the inner integument initiates earlier than the outer. The initials of both the integuments are two celled thick. These cells divide repeatedly by transverse walls resulting in the formation of two layered integuments (Fig. 15–17). The outer integument remains two layered but the inner integument becomes 4–6 layered in a mature ovule. Micropyle is formed by both the integuments (Fig. 18).

The ovule possesses a massive nucellus. At the organised embryo sac stage about 4 to 6 apical nucellar epidermal cells elongate radially and undergo periclinal divisions resulting in a two layered nucellar cap (Figs. 18, 19).

Megasporogenesis and female gametophyte. The hypodermal archesporium, although is two or three celled (Fig. 20) only one of them develops further and undergoes a periclinal division cutting off a primary parietal cell towards the periphery and a megaspore mother cell towards inner side (Fig. 21). As a result of meiotic division in the megaspore mother cell a linear tetrad of megaspores is formed of which the chalazal one is functional and produces an eight nucleate embryo sac of the *Polygonum* type (Figs. 22–26). The egg apparatus comprises an egg and two pear shaped synergids. The two polars fuse at the



Figs. 19–33. 19. Micropylar region of nucellus showing a part of mature embryo sac. 20, 21. Nucellus showing archesporium and megaspore mother cell stages respectively. 22. Linear megaspore tetrad. 23–26. Successive stages in the development of embryo sac. 27. Embryo sac showing syngamy and primary endosperm nucleus. 28. Embryo sac showing the 2-celled proembryo, and endosperum nuclei. 29, 30, 33. Successive stages in the development of embryo and endosperm. 31. Longitudinal section of part of seed showing hypostase. 32. Cellular endosperm showing starch grains. ce: cellular endosperm; f: funicle; h: hypostase; ii: inner integument; iii: initials of inner integument; n: nucellus; ne: nuclear endosperm; oi: outer integument; pen: primary endosperm nucleus; sg: starch grains; sp: sperm nucleus; t: testa; tg: tegmen; v: vasculature.

centre of the embryo sac. The three uninucleate antipodal cells are small and ephemeral.

Although the ovular primordium initiates after completion of the second meiotic division in the pollen mother cells (Fig. 1), it is interesting to note that the ovule development is very fast and by the time the pollen is shed the female gametophyte is organised and the stigmatic head is ready to receive the pollen.

Anthesis, pollination and pollen germination. In about 6 to 7 days after its inception the flower bud is ready for bloom. Anthesis occurs between 5.30 A.M. and 6.00 A.M. and the anthers dehisce at 8.00 A.M. Flies and ants serve as pollinating agents. Both self and cross pollination are prevalent.

In vitro pollen germination studies suggest that 15% sucrose solution is the optimum concentration where about 96% of the pollen germinate and also the pollen tube growth is maximum attaining a length of 34.65 microns. Pollen inoculated into the nutrient media immediately after anthesis i.e. at 8.00 A.M. show a good percentage of germination and tube growth, whereas pollen incubated into nutrient media at 11.00 A.M. show poor percentage of germination and tube growth. This suggests that the pollen loses its viability within 3 to 4 hours after anthesis.

Fertilization. The entry of pollen tube into the ovule is porogamous. It discharges its contents at the vicinity of the egg. Triple fusion occurs immediately after discharge of the sperms while syngamy occurs 5 to 6 hours later (Fig. 27).

Development of seed. After fertilization a number of histogenic changes take place in the young seed. The curvature of the ovule is further accenuated by the rapid growth of the cells at the funicle and chalaza and this region subsequently forms the raphe (Figs. 29, 30, 33).

Nucellus. Following fertilization, meristematic activity is initiated both in the chalazal and micropylar regions of the nucellus. However, due to excessive unilateral growth at the chalazal end, the nucellus becomes curved (Fig. 29).

The nucellus is consumed by the growing embryo sac and in a mature seed 2 to 3 layers of nucellus persists as perisperm (Figs. 30, 33).

Hypostase. After fertilization a group of nucellar cells at the chalazal end of the ovule develop thick walls, and differentiate into hypostase. The cells accumulate tannin. The hypostase is connected to embryo sac on one side and to the vasculature on the other side (Fig. 31).

Endosperm. The primary endosperm nucleus becomes mitotic soon after its formation and 16 to 18 free nuclei are formed within 26 to 30 hours after fertilization (Fig. 28). By further free nuclear divisions a large number of nuclei are formed which are arranged towards the periphery of the embryo sac (Fig. 29). Cellularisation occurs by the time a heart-shaped embryo is formed (Fig. 30). The endosperm cells are rich in starch (Fig. 32). In a mature seed 1 to 4 layers of endosperm remain persistent (Fig. 33).

Embryogeny. The embryogeny follows Onagrad pattern. The zygote remains sedate for about 20 to 24 hours and undergoes its first division only after 12 to 16 endosperm nuclei are formed. Growth of the embryo is slow in the initial stages but later it becomes active. About 4 days after fertilization an eight celled proembryo is formed. A globular embryo is formed on the 5th day (Fig. 29) and the cotyledons are differentiated around the 7th day. Growth of the embryo continues and by 10th day after fertilization the embryo matures and occupies the entire embryo sac (Fig. 33). On the 14th or 15th day the capsule breaks open along the margins of the two carpels and liberates the seeds.

Discussion The anther wall development in *Cleome monophylla* (Rao 1967), *Niebuhria apetala, Capparis divaricata* (Arunalakshimi 1985a, 1985b) and *Cleome aspera* (present report) follows Dicotyledonous type. However, *Cleome tenella, Capparis decidua* (Hanumantha Rao & Prakasa Rao 1975a, 1977), *Capparis grandis* and *C. sepiaria* (Arunalakshmi 1985b) show Basic type of anther wall development. Thus, it appears that both Dicotyledonous and Basic types of anther wall development are common to this family. It is interesting to note that different species of the same genus differ in their wall development.

The members of the family are characterised by campylotropous, bitegmic and crassinucellate ovules. In the family Capparaceae hypostase is recorded in *Capparis decidua, Crataeva nurvala* (Narayana 1962, 1965), *Niebuhria apetala, Capparis divaricata, Cleome chelidonii, C. monophylla* (Arunalakshmi 1985b) and *C. aspera* (present authors). It is interesting to note that in all these members the differentiation of the hypostase is a post-fertilization event.

The two hitherto investigated genera, *Capparis* and *Cleome*, vary in the size and shape of synergids. In the former the synergids are long, flask shaped, hooked and are provided with filiform apparatus (Rao 1938; Narayana 1962, 1965; Arunalakshmi 1985a, 1985b), while in the latter they are small, pear shaped and without hooks and filiform apparatus (Rao 1967; Fathima & Kumari

1970; Arunalakshmi 1985b and present report).

The family exhibits great diversity regarding embryogeny. Taking note of the observations of Mauritzon (1934), Johansen (1950) states that embryogeny in *Capparis frondosa*, *Cleome monophylla*, *C. serrata*, *Gynandropsis pentaphylla*, *Polanisia graveolens* and *P. trachysperma* follows the Alyssum variation of the Onagrad type. In *Gynandropsis pentaphylla* (Phouphas 1952) the embryo development is very similar to that of *Myosurus minimus*. The embryogeny in *Isomeris arborea* (Sachar 1956) and *Crataeva nurvala* (Narayana 1965) follows Solanad type while in *Cadaba indica* (Narayana 1965) it conforms to Caryophyllad type. According to Narayana (1962) the embryo development in *Capparis decidua* shows resemblances to Onagrad, Solanad and Caryophyllad types. Embryogeny in *Cleome chelidonii* (Raghavan 1937), *C. tenella* (Hanumantha Rao & Prakasa Rao 1975b), *C. aspera* (Prakasa Rao & Hanumantha Rao 1976), *Niebuhria apetala* and *Capparis divaricata* (Arunalakshmi 1985a, 1985b) conforms to Lythrum variation of the Onagrad type.

From the foregone, it is apparent that the family is embryogenically heterogenous and provides valuable information on the possibilities of applying the science of embryo development to the taxonomy.

One of us (VAL) is grateful to the Council of Scientific and Industrial Research, New Delhi for the award of Senior Research Fellowship.

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フウチョウソウ属の *Cleome aspera* の花粉，胚嚢，胚乳形成を報告した。またこの科の胚形成をいままでの報告から総括すると様々な型が見られる。*Capparis frondosa* などでは Onagrad type の Alyssum variation である。*Crataeva nurvala* などは Solanad type, *Cadaba indica* は Caryophyllad type である。また *Capparis divaricata* や *Cleome aspera* などは Onagrad type の Lythrum variation であるなど，同一属でも異なる型が見られる。この事は胚形成がこの科の分類に価値のある情報を提供するものと思われる。

□Duncan, W.H. & M.B. Duncan: **Trees of the southeastern United States** 322 pp. 1988. Univ. Georgia Press. ¥3,990. 本書での tree の定義は，少なくも高さ 4 m, 胸高直径 7.5 cm の多年生の茎をもつ植物としてある。まず葉の形質のみによってAからKの11群に分け，各群内で属，必要ならばさらに種の検索表がついており，ところどころに科や属全体の検索表がある。したがって植物は分類順には並んでいない。同定形質としては徹底的に葉や枝の形質を用い，よほどのことがない限り果実や花の形質は避けている。各種についてはかなり詳しい記述とともに，州単位の分布図を付し，分布量を二つのサイズの点で示してある。カラー写真もよい出来である。日本と関係のある地域であり，本の構成も参考になるので紹介する。 (金井弘夫)